Geophysical Survey of the St. Marys River at Sault Ste. Marie, Ontario

April 2000

Ontario

Ministry of the Environment

101-00571/

Geophysical Survey of the St. Marys River at Sault Ste. Marie, Ontario

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April 2000

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Printed on 50% recycled paper including 10% post-consumer fibre

ISBN 0-7794-0224-3

PIBS 4084E

DISCLAIMER

This report was prepared for the Ontario Ministry of Environment and Energy (now the Ontario Ministry of the Environment) as part of Contract P.O. Number 011055. Additional field information has been added to the original document.

The views expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ontario Ministry of the Environment, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

McQuest Marine Sciences was contracted by the (then) Ontario Ministry of Environment and Energy (OMOEE) to perform a geophysical survey in the St. Marys River at Sault Ste. Marie, Ontario. The field work was conducted from September 25 through 27, 1995. The work reported on herein forms part of a larger study incorporating sediment sampling and benthic community assessment carried out in the Sault Ste. Marie, Ontario area during September, 1995 (Kauss, 1995).

Side scan sonar proved to be an effective means for determining the surface lithology within the two study areas - the Algoma Slag Dump-Algoma Slip area and the Bellevue Marine Park area. It is a useful tool for locating areas of fine sediment deposition. Side scan sonar is also capable of revealing known or unknown anthropogenic features such as pipelines, outfalls, intakes, anchor scouring, tires, debris, logs, dredge spoil, etc..

Due to the gaseous nature of the sediments in the two study areas, acoustic sub-bottom profiling methods of determining overburden thickness generally proved to be ineffective. However, the information these systems provided was useful in determining the extent and degree of gas coverage in the sediments within the study area.

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1. INTRODUCTION

McQuest Marine Sciences was contracted by the Ontario Ministry of the Environment and Energy (OMOEE) to perform a geophysical survey in the St. Marys River at Sault Ste. Marie, Ontario. The field work was conducted from September 25 through 27, 1995.

2. METHODS

The survey vessel and positioning system were provided by the OMOEE. The survey vessel, the ***MONITOR VI***, was equipped with a *Trimble*® differential global positioning system (DGPS) and a navigation software package called *Hydro*®. A DGPS shore station was established and maintained by OMOEE personnel throughout the entire survey. All survey planning and logging of positional data was conducted using *Hydro*.

McQuest supplied a *Klein* 595 Side Scan Sonar System (100 kHz, 3/4 degree), a *Klein* Sub-bottom Profiler (3.5 kHz), and a *DataSonics* Sub-bottom Profiler (Bubble Pulser, 0.4 kHz). The side scan and sub-bottom profiling systems were outfitted on the ***MONITOR VI*** and all equipment was interfaced to *Hydro* in order to provide positional fix annotation on all paper records.

Two areas were surveyed. One of these (approximately 2.2 km by 1.4 km) is located in Bellevue Marine Park (see Fig. 1, Area 1). The other area (approximately 2.8 km by 0.4 km) was located offshore of the Algoma Slag Dump and extended into the Algoma Slip (see Fig. 1, Area 2).

In the Bellevue Marine Park area, twenty-two survey lines were run offshore/inshore at a 75 metre line spacing. Positional fixes were logged in *Hydro* and annotated on the records every 25 metres along line. Three check lines were run upriver/downriver at a line spacing of 100 metres with positional fixes every 25 metres along line.

In the Algoma Slag Dump area, six survey lines were run upriver/downriver at a 75 metre line spacing. Positional fixes were logged in *Hydro* and annotated on the records every 25 metres along line. Several lines were run at varied distances from and parallel to the dock inside the Algoma Slip with positional fixes being taken every 25 metres.

3. RESULTS AND DISCUSSION:

3.1 Surficial Sediment Characteristics

Using the positional data from *Hydro* and *Generic* CADD® (a computer automated design and drafting software package), a track plot was created for the two areas surveyed (see Appendix

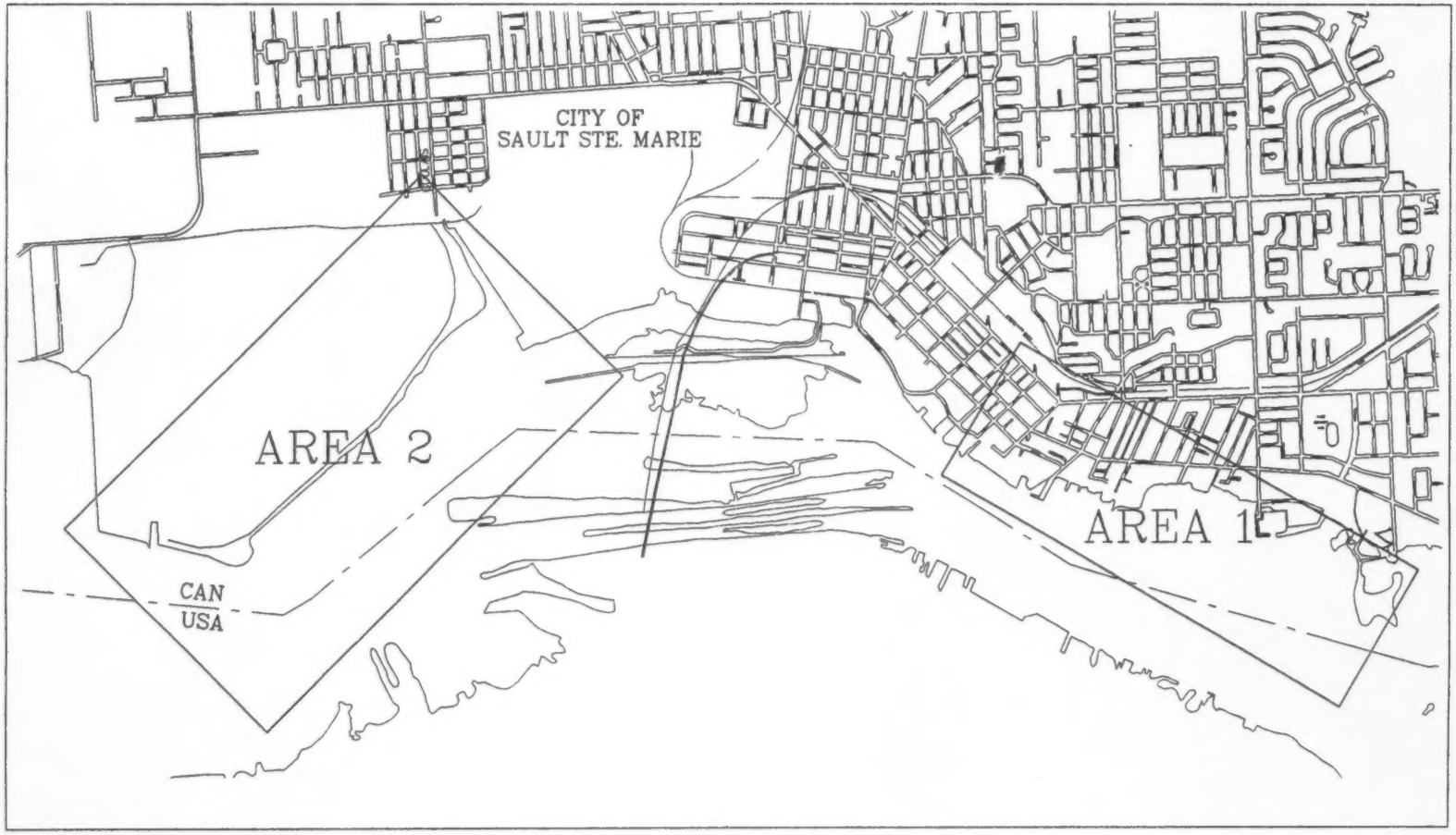

Figure 1. Survey Areas: Area 1 (Bellevue Marine Park); and Area 2 (Algoma Slag Dump - Algoma Slip).

A, Drawing A1; Appendix B, Drawing B1). A lithological interpretation was performed for each area using these track plots and the respective side scan sonar records. The results are presented in Figures 2 and 3. The purpose of these lithological interpretations was to map the distribution and types of surface sediments in each area. Anthropogenic targets (e.g., anchor drags, tires, debris, etc.) were also revealed by the side scan records and are presented in Figures 4 and 5. Initially, the various sediment types encountered were classified based on the interpreter's prior experience from side scan data and 'ground truthing' results collected in other areas. Initial results were shown to the client, P. Kauss of the OMOEE. It was jointly decided at this time to compare the side scan sonar lithological interpretation to the 'ground truthing' results of the Bellevue and Algoma areas collected earlier in September by OMOEE. It was also decided to compare the lithological interpretation to the preliminary *Roxanne*® (an acoustic bottom discrimination system; see for e.g., Rukavina, 1996) data of the same areas collected two weeks earlier by the National Water Research Institute (NWRI), Canada Centre for Inland Waters (N. Rukavina, pers. comm., Sept. 1995). The "ground truthing" results consisted of several sample site locations (see Appendix A, Drawing A2; and Appendix B, Drawing B2), with accompanying sample descriptions, photographs of cores and grab samples, as well as underwater video observations obtained by diver or *Mini Rover*® submersible. The ground truthing results are tabulated in Appendix C. Photographs and videos are on file at the Environmental Monitoring and Reporting Branch, Water Monitoring Section office in Etobicoke (contact P. Kauss).

For the Bellevue and the Algoma Areas, the lithological interpretations agreed very well with the ground truthing results. Some minor discrepancies were likely due to the following:

a) the sample site being located right on a transitional zone from one lithological classification type to another.

b) the sample site being located in an area with 100 % weed cover. In such areas, side scan sonar can detect the weeds but is not able to reveal the underlying material.

In the Algoma Slip, ground truthing indicated that the bottom actually consists of a combination of sand, coal fragments, pelletized ore, slag, and debris on a clay material. Initially, the lithological interpretation referred to this classification as a combination of sand, gravel, cobble and small boulders on glaciolacustrine clay with some scattered debris. The classification was changed on the lithological interpretation in order to reflect the ground truthing results.

The preliminary *Roxanne* data showed the same general zone delineations as the side scan lithological interpretations. However, many of the names of lithological classifications provided by *Roxanne* did not agree with the side scan results and the 'ground truthing' results. This is likely due to the fact that the classifications used in the preliminary *Roxanne* data had not yet been adjusted or calibrated to reflect the 'ground truthing' results for this area. Minor observed differences in zone delineations are likely due to the fact that the side scan sonar provides 100 % bottom coverage from line to line and throughout the surveyed areas. The *Roxanne* system, on

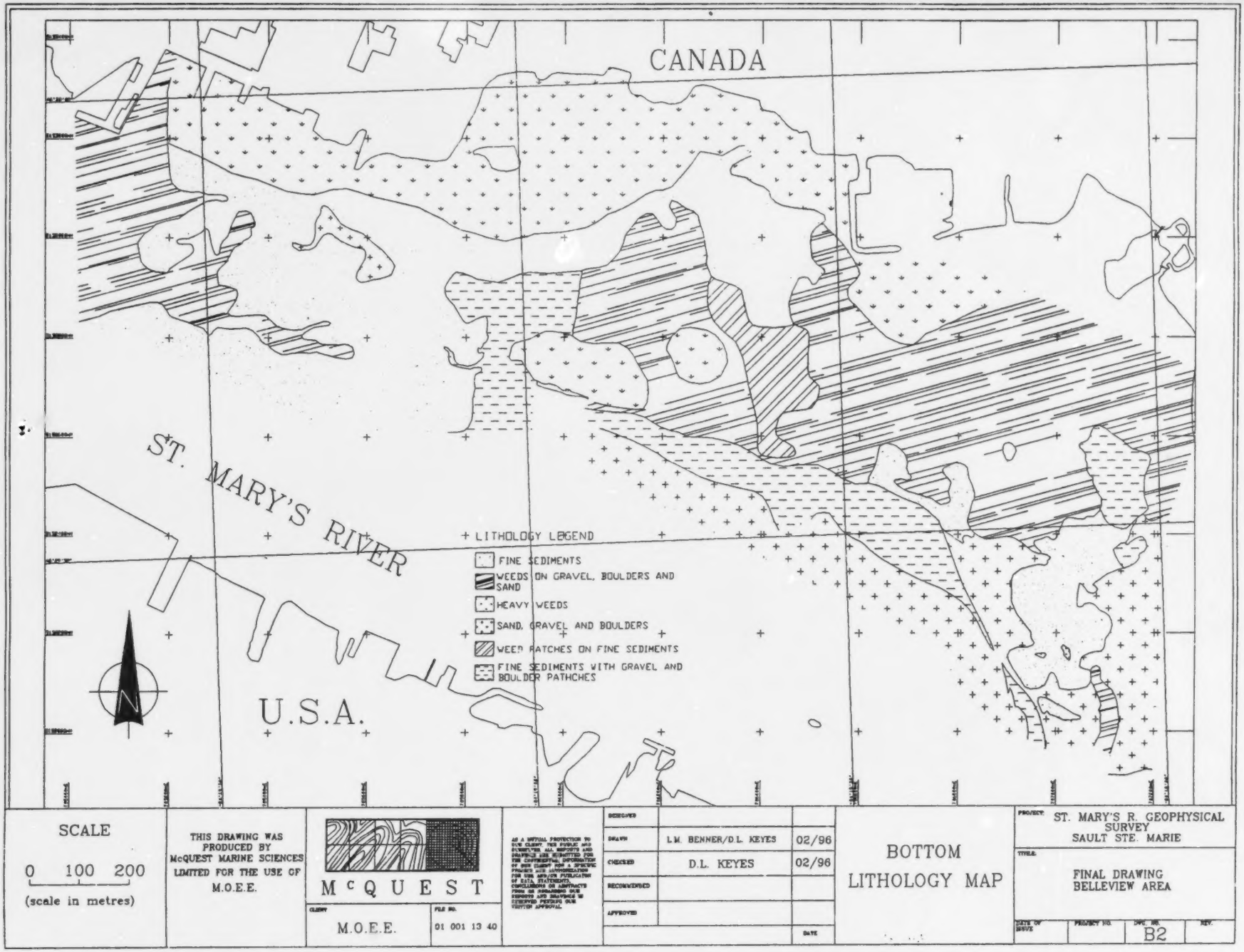

Figure 2. Bottom lithology map of the Bellevue Marine Park area.

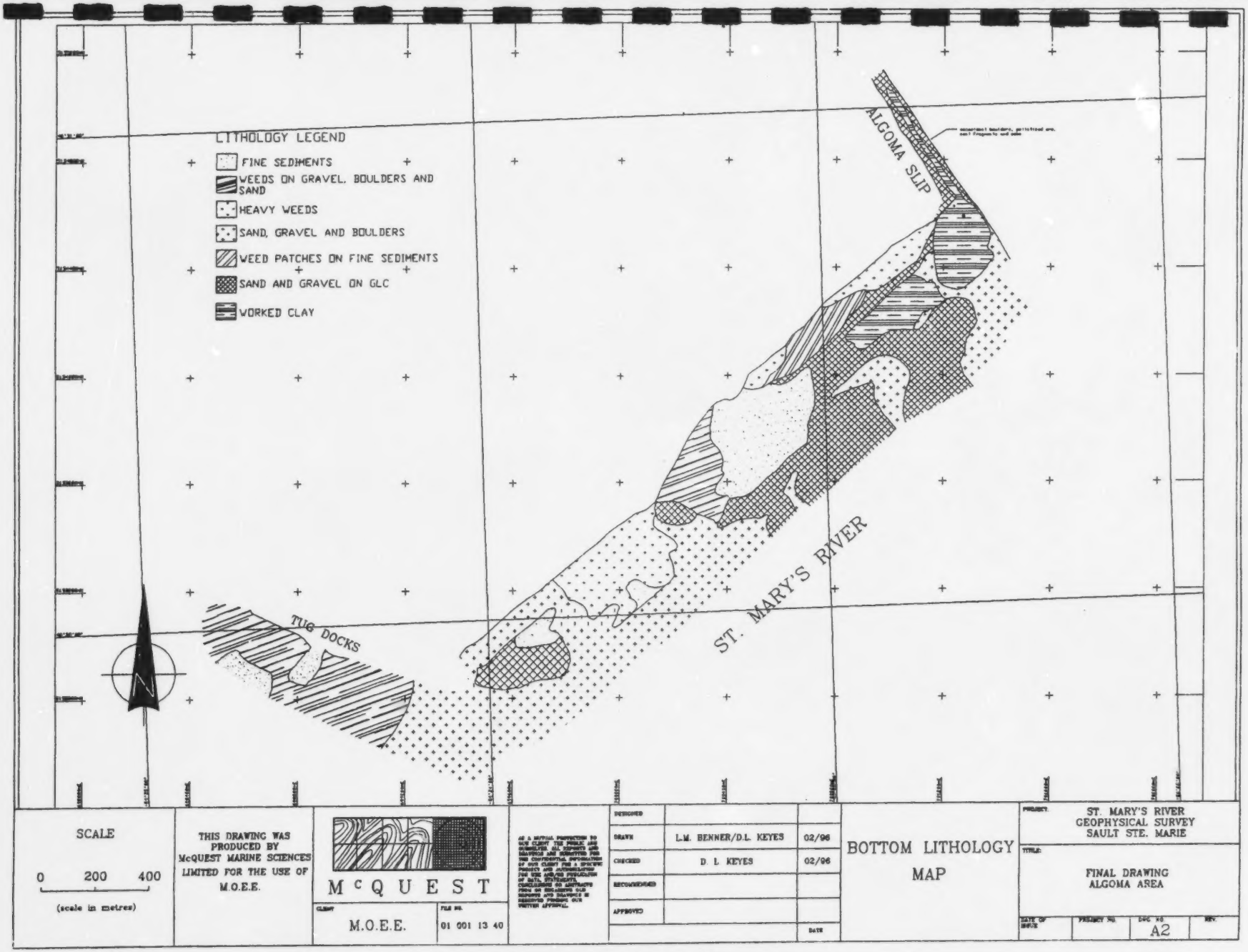

Figure 3. Bottom lithology map of the Algoma Slag Dump - Algoma Slip area.

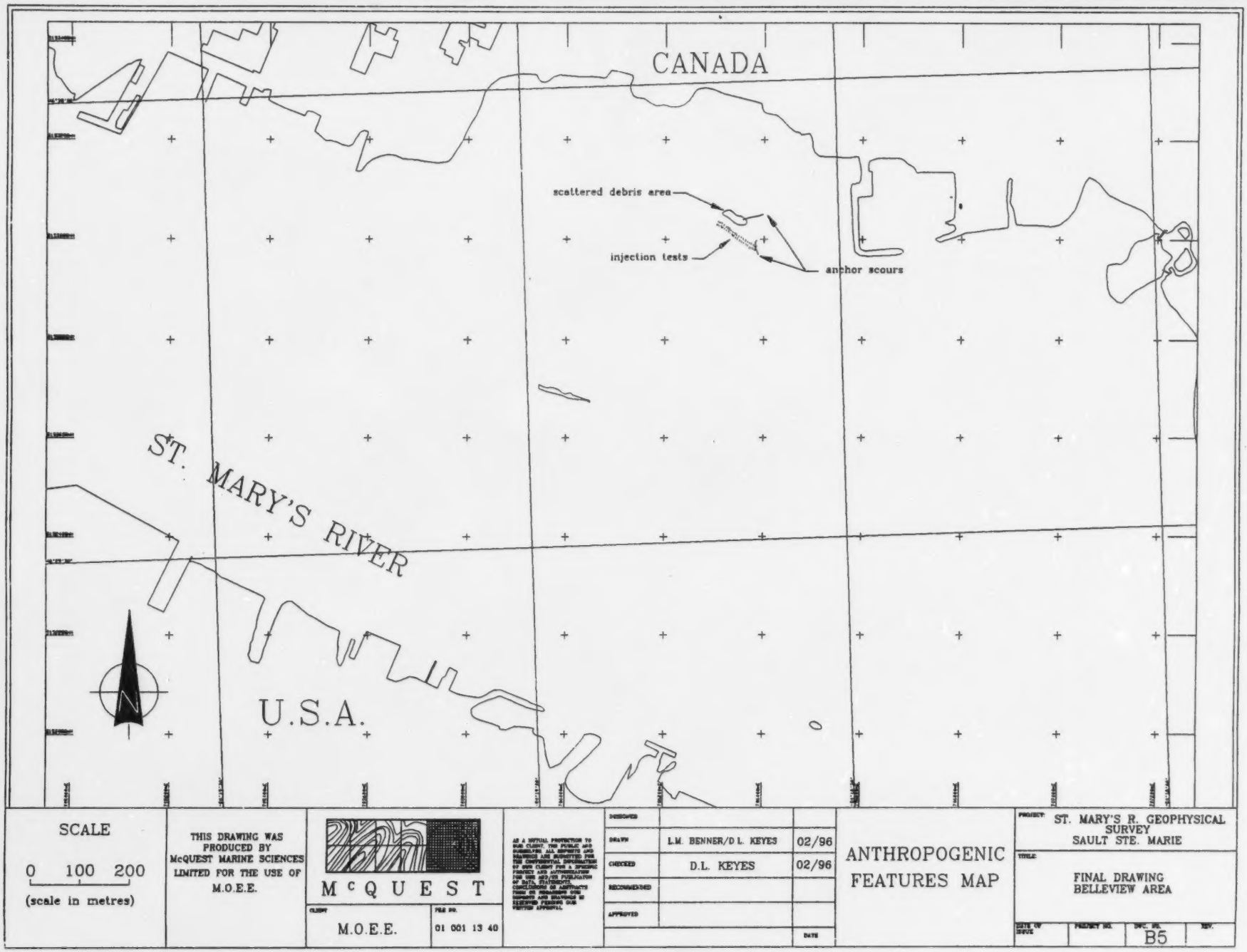

Figure 4. Anthropogenic features map of the Bellevue Marine Park area.

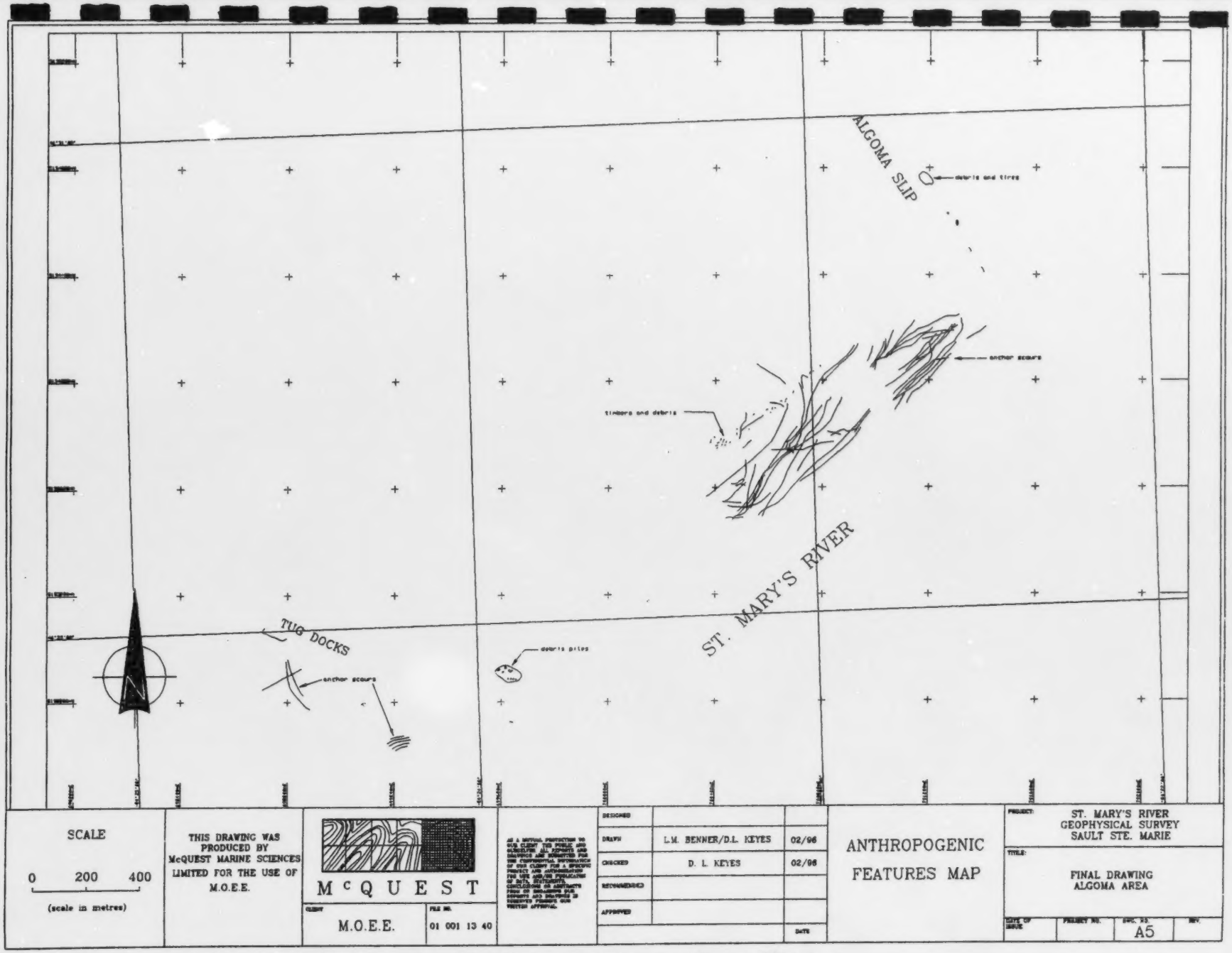

Figure 5. Anthropogenic features map of the Algoma Slag Dump - Algoma Slip area.

the other hand, has limited bottom coverage that is a function of the echo sounder transducer cone angle and its height above the bottom. This limited bottom coverage greatly restricts the maximum line spacing distance, especially if the data is to be represented accurately (i.e., the coloured pixel of *Roxanne* information is to represent the true dimensions of the transducer's footprint on the river bottom).

3.2 Sub-Bottom Sediment Characteristics

The sub-bottom profile data, both from the *Klein* and the *DataSonics* systems, was interpreted and the overburden thickness was marked on each track plot wherever it could be determined.

Sub-bottom profile data in the Bellevue area was generally poor with little or no bottom penetration due to gaseous sediments, shallow water, and extensive weed coverage. The *Klein* system provided better results than the *DataSonics* system in this area. A bottom penetration map was prepared (see Fig. 6). This bottom penetration map shows the following zone types:

a) no penetration due to weeds and gas.

b) partial penetration due to gas masking.

c) no penetration due to bottom type and/or lack of overburden.

d) penetration to bedrock or till.

In areas with partial penetration due to gas masking, the number of overburden thickness values that could be determined was insufficient to produce a contoured plan. The overburden thickness values in this area ranged between at least 0.5 and 2.0 metres, but could have been greater since partial gas masking prevented further bottom penetration. In areas with penetration to bedrock / till, the number of overburden thickness values that could be determined was also insufficient to produce a contoured plan. The overburden thickness values in this area ranged from 0.5 to 1.5 metres.

Sub-bottom profile data in the Algoma area was good in the offshore areas with penetration up to 24 metres in the glaciolacustrine clays. Again the *Klein* system provided better results than the *DataSonics* in this area. A bottom penetration map was prepared (see Fig. 7). This bottom penetration map shows the following zone types:

a) no penetration due to weeds and gas.

b) partial penetration due to gas masking.

c) no penetration due to bottom type and / or lack of overburden.

d) penetration to bedrock or till.

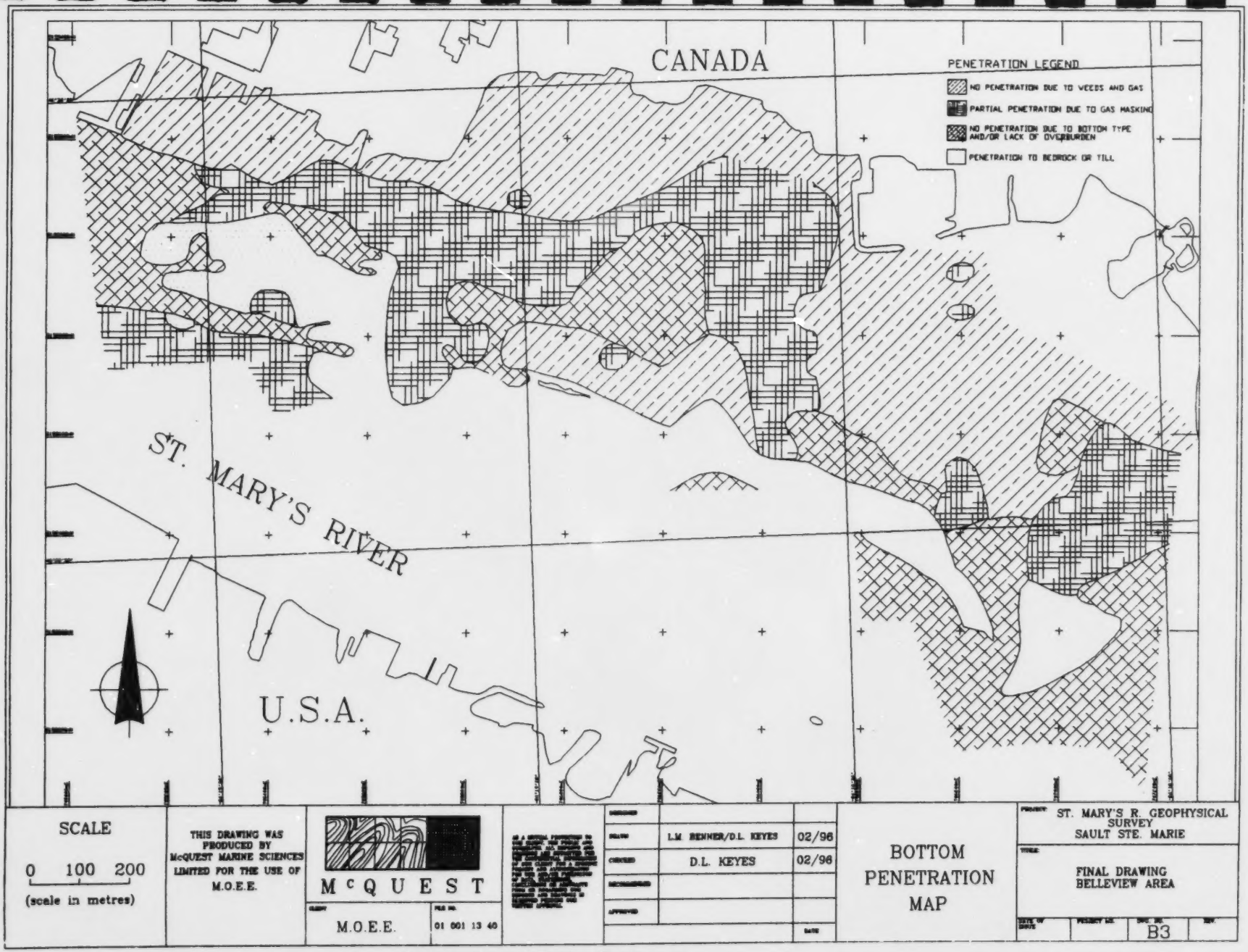

Figure 6. Bottom penetration map of the Bellevue Marine Park area.

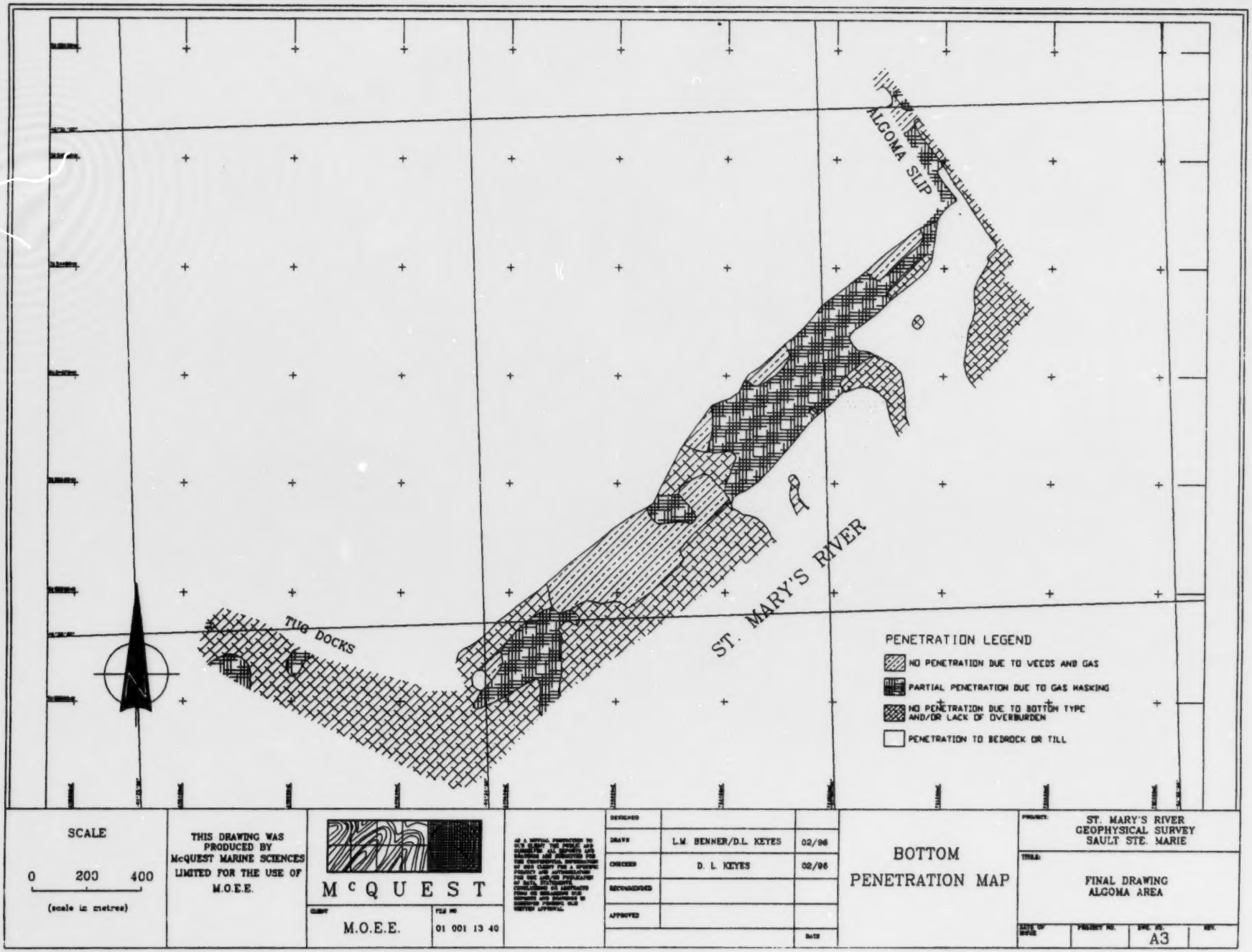

Figure 7. Bottom penetration map of the Algoma Slag Dump - Algoma Slip area.

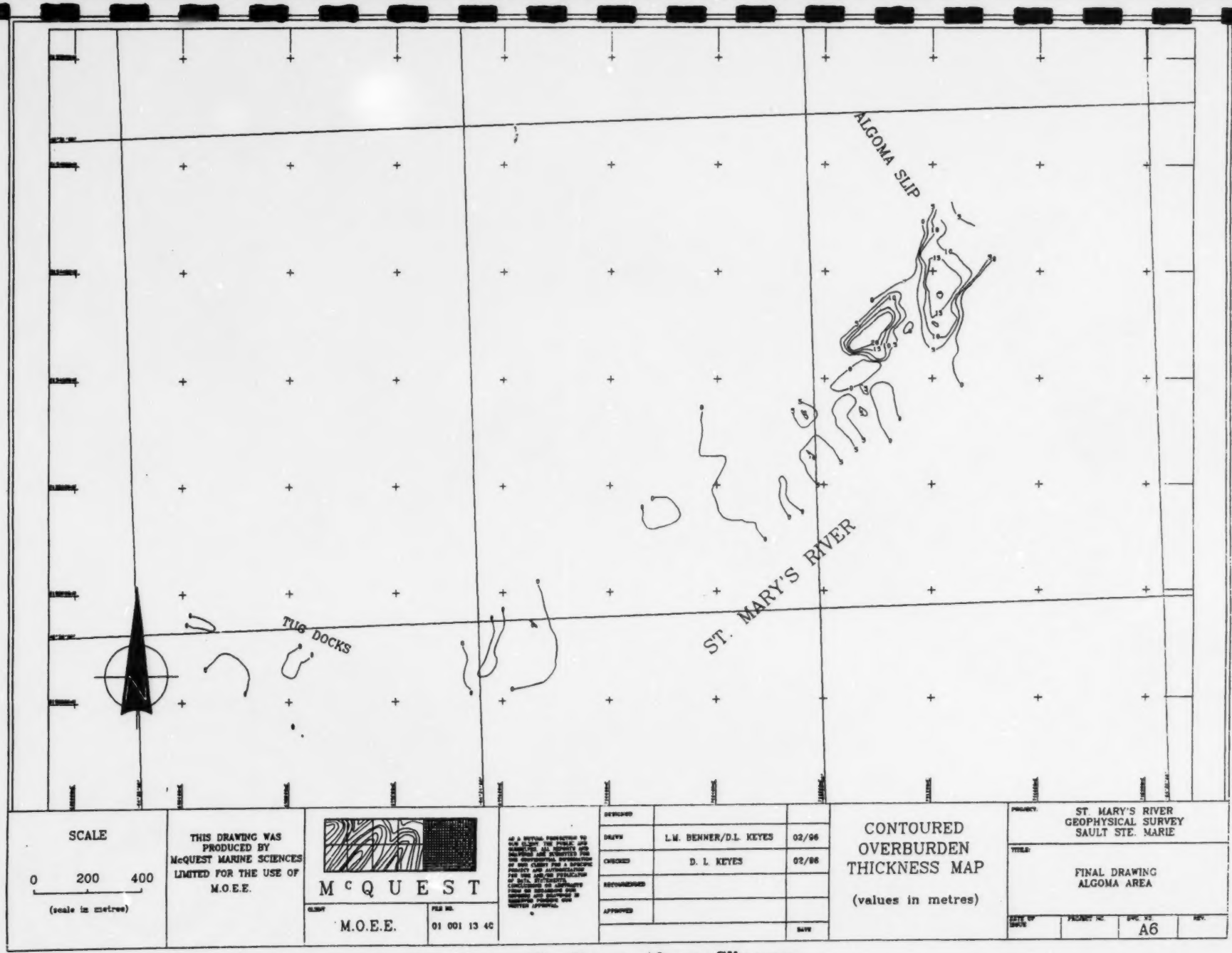

Figure 8. Overburden thickness map of the Algoma Slag Dump - Algoma Slip area.

Little or no bottom penetration was achieved in areas with gaseous sediments and/or shallow water and/or heavy weed cover. It was not possible to determine overburden thicknesses in the Algoma Slip due to side reflections from the dock walls. In areas where sufficient overburden thickness values could be determined, it was possible to provide contouring of these values (see Fig. 8). Where penetration to the bedrock/till horizon was possible, the bottom sediments consisted predominantly of clays.

All manually interpreted maps were digitized using a full size *Summagraphics*® digitizing tablet. The digital files were then imported into *Generic* CADD. Digital shoreline files provided by OMOEE, were also converted and imported into *Generic* CADD. Using *Generic* CADD, a final drawing was created for each of the areas surveyed. A detailed description of the layer structure of the final drawings for the Bellevue and Algoma area is provided in Appendix D.

The following additional deliverables were provided to the client:

- a .dxf and .dwg computer file of the final drawing for the Bellevue Marine Park area; and
- a .dxf and .dwg computer file of the final drawing for the Algoma Slag Dump-Algoma Slip area.

4. CONCLUSIONS:

Side scan sonar has proven to be an effective means for determining the surface lithology within a given study area. It is a useful tool for locating areas of fine sediment deposition. It is also capable of revealing known or unknown anthropogenic features such as pipelines, outfalls, intakes, anchor scouring, tires, debris, logs, dredge spoil, etc..

In the two study areas, due to the gaseous nature of the sediments, both acoustic means of determining overburden thickness proved generally ineffective. However, the information these systems provided was useful in determining the extent and degree of gas coverage in the sediments within the study area.

5. RECOMMENDATIONS:

It is highly recommended that a side scan sonar survey be performed prior to conducting a "ground truthing" or bottom sampling program in any study area. The information the side scan sonar can provide is invaluable in preparing a sound sampling strategy. Determining beforehand where and how many samples are required can save a lot of time and money in field and analytical costs. Also, it ensures that all areas of interest are sampled and not overlooked by a "best guess" sampling strategy. Side scan sonar can also provide information on anthropogenic features that may influence the sampling strategy. In summary, side scan sonar provides good baseline information and a solid background knowledge in the area of concern.

Acoustic sub-bottom profiling techniques proved generally ineffective in these two study areas, due to gas created by organic decomposition of bottom materials. The gas (being an excellent acoustic reflector) created an impenetrable layer that prevented the determination of overburden thickness in many cases. As a result, it is recommended that other means of sub-bottom penetration (e.g., ground pulse radar) be investigated for the purpose of determining overburden thickness in areas likely to exhibit gaseous sediments.

6. REFERENCES:

Kauss, P.B., 1995. St. Marys River Sediment Impact Zone Characterization Project Description. Ontario Ministry of Environment and Energy, Environmental Monitoring and Reporting Branch, Surface Water Section. August 18, 1995. 21 pp.

Rukavina, N.A., 1996. Bottom Sediments of the St. Clair River at Sarnia, Ontario. Environment Canada, National Water Research Institute, New Technologies Research Branch. NWRI Contribution No. 96-200. 9 pp. + figures, table and appendix.

APPENDIX A

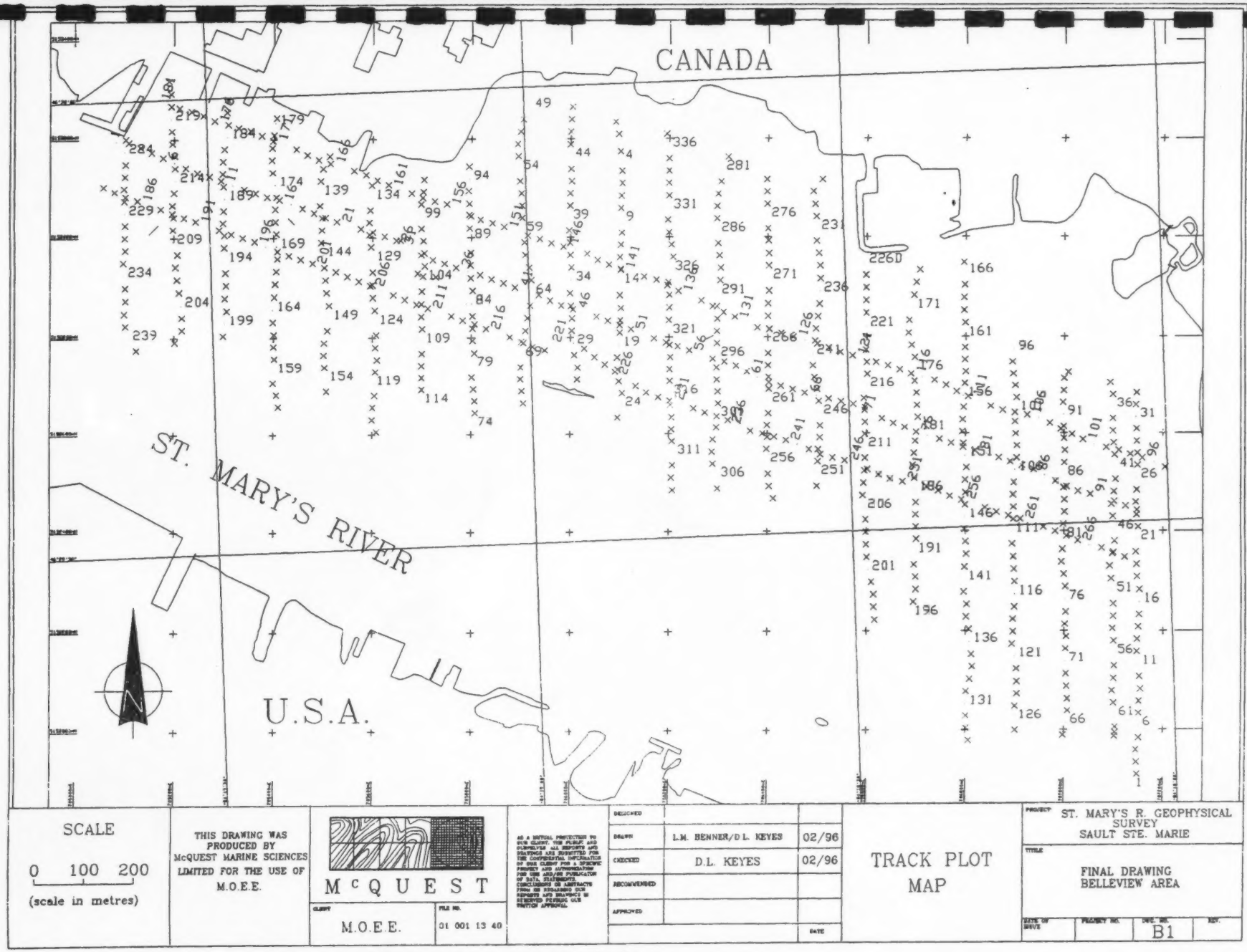

Figure A-1. Survey line track plots for the Bellevue Marine Park area.

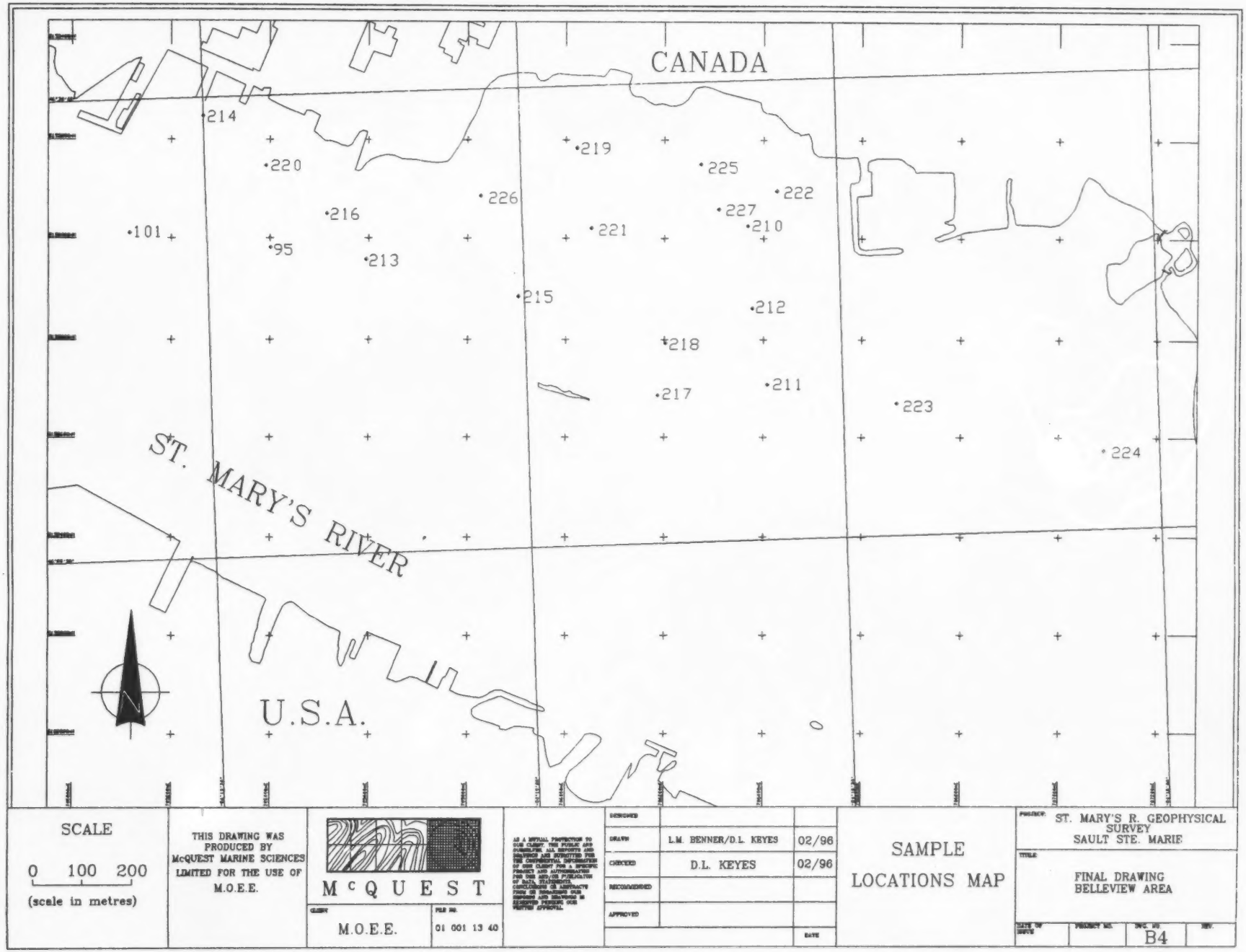

Figure A-2. Sediment sampling locations in the Bellevue Marine Park area.

APPENDIX B

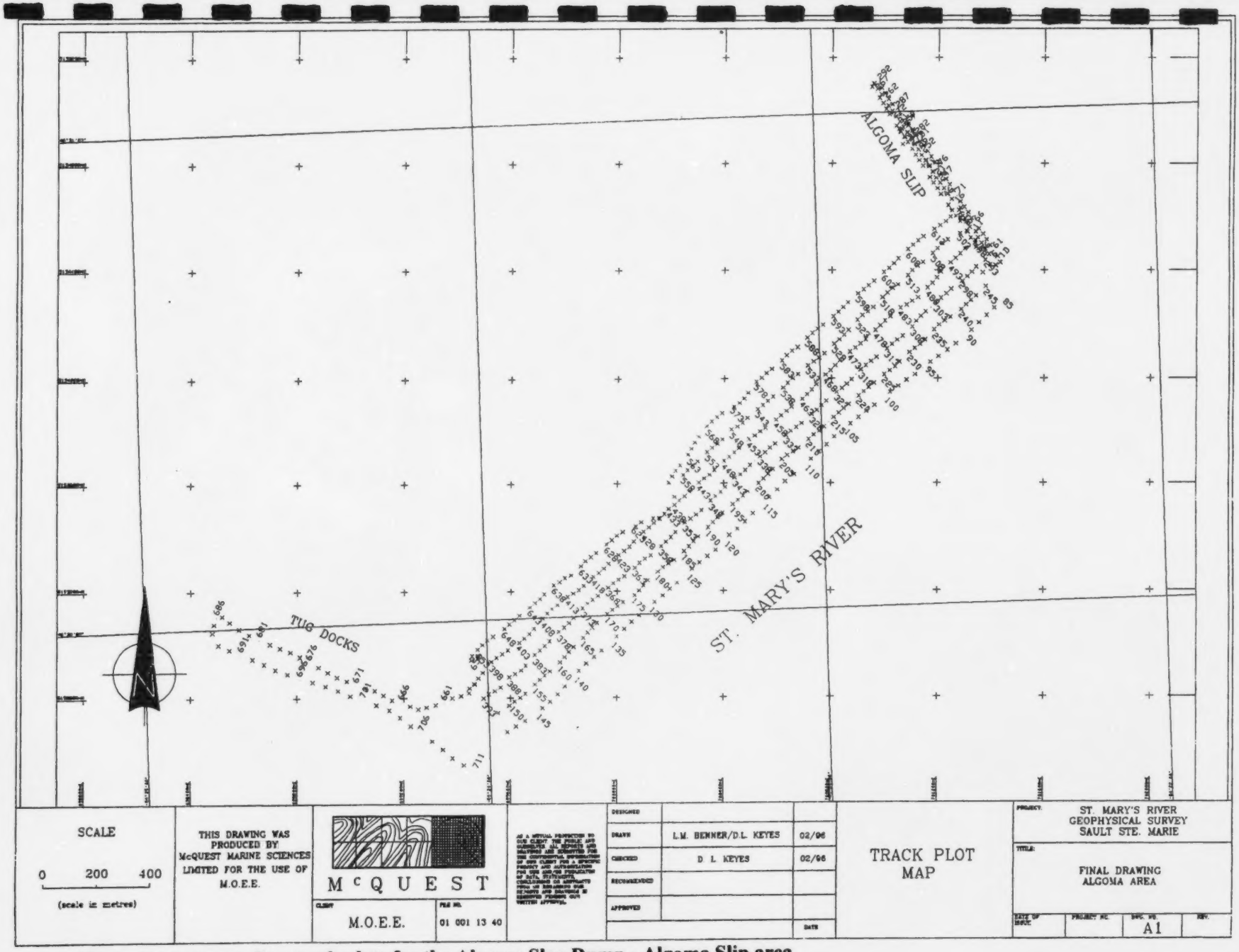

Figure B-1. Survey line track plots for the Algoma Slag Dump - Algoma Slip area.

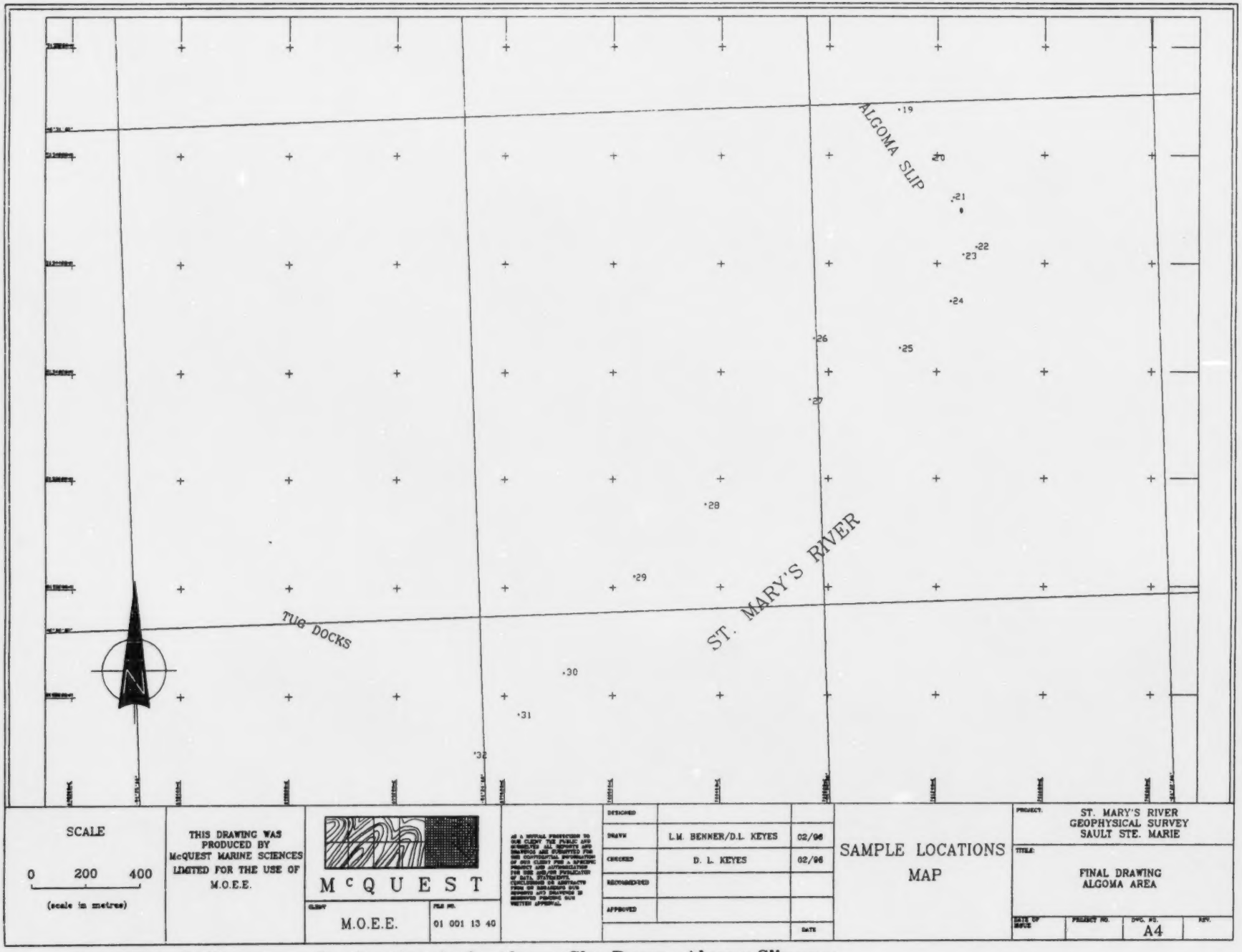

Figure B-2. Sediment sampling locations in the Algoma Slag Dump - Algoma Slip area..

APPENDIX C

Table C-1. Bellevue Marine Park, Algoma Slag Dump and Algoma Slip ground truthing field notes.
(Datum is NAD-27; accuracy for all fixes/locations is +/- 5 metre accuracy, except for 95 & 101 which is sub-metre).

GPS Fix Number	Date (Yr/Mo/Day)	Water Depth (metres)	Current Speed at 0.15 metres off bottom (metres/second)	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth (metres)	Nature & Amount of Material on end of Sediment Depth Probe	UTM Coordinates (metres) Northing	UTM Coordinates (metres) Easting	Record
95	95/09/22	7.6	0.34	2 metre visibility; sand, some wood debris & potted depressions; smooth, flat surface;	0.50	none (no clay)	5152981.05	705400.78	video
			0.32	sparse vegetation & dead vegetation on surface; Core: fine sand, oil sheen, no odour; harder packed at 5 cm depth;	0.40	"			
			0.37	one large wood chip.	0.40	--			
			--		0.35	"			
101	95/09/23	7.0	1.16	1.5-2.4 metre visibility sandy (orange-tinge) with patchy rocks (75 %) & vegetation; in-fill	0.25	--	5153010.39	705116.01	video
			1.00	(silty surface) behind boulder; Core: some minor gas bubbling; small *Hydra* on sediment surface;	0.15	--			
			1.79	granular sand; little (~ 5%) pea-size gravel; orange-tinge; no sheen; no odour	0.15	--			
19	95/09/23	7.3	0.08	alongside John B. Aird (off-loading coal); zero visibility;	1.00	none	5154967.97	701056.23	video & photo
			0.09	bottom feels like coarse sand with palm-size cobble; Core: 20 cm long (compacted 23 %); clay mixed with coarse & fine	1.20	"			
			0.12	coal (2 cm max.); oil sheen; pink-red clay patches; strong petrochemical odour.	1.15	"			
20	95/09/23	9.1	0.05	zero visibility; bottom feels flagstone-like (perhaps concrete) with few softer areas;	0.50	red clay at 0.5 m	5154786.77	701184.47	video & photo
			0.12	Core: 30 cm long (compacted 23 %); very hard red clay mixed with fine coal; oil sheen; strong petrochemical odour.	0.50	"			
			0.04		0.75	"			
			--		0.40	"			
21	95/09/23	9.1	0.18	approx 0.1 metre visibility; cobble-size rocks over clay; clay with dusting of sand in pickets;	1.50	all clay	5154644.38	701263.03	video & photo
			0.12	Core: 27 cm (no compaction); all red-pink clay; very dense.	1.50	"			
			0.09		1.50	"			
			--		1.60	"			

GPS Fix Number	Date (Yr/Mo/Day)	Water Depth (metres)	Current Speed at 0.15 metres off bottom (metres/second)	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth (metres)	Nature & Amount of Material on end of Sediment Depth Probe	UTM Coordinates (metres) Northing	UTM Coordinates (metres) Easting	Record
22	95/09/23	8.5	-- -- -- --	1.0 metre visibility; very slippery clay; flat; no debris: Core: 27 cm. (no compaction); no odour.	1.00 >3.31 >3.31 >3.31	all clay " " "	5154460.12	701346.73	video & photo
23	95/09/23	8.7	very slight north-east	hard clay bottom (diver in "crater" area); Core: 19 cm. (no compaction); all pink clay.	1.60 1.20 1.50	all clay " "	5154433.54	701297.56	NA (no core)
24	95/09/23	10.8	little current	1.5 metre visibility; slab rock & clay with crushed rock (65 % small pea gravel/35 % cobble size & greater i.e., small boulders); appearance of recent dredging; Core: 10 cm. (no compaction); coarse gravel & clay mix; no odour or oil sheen.	0.30 0.20 0.25	-- -- --	5154258.97	701252.12	video & photos
25	95/09/23	11.9	no current	visibility 2.5 metres; loose, slippery, silty surface over clay; some cobbles; <5 % filamentous algae; very homogeneous area; Core: 19.5 cm. (compacted 11 %); 1 cm. loose sand/silt with algae over packed, fine sand with 5-10 % silt.	0.60 0.65 0.50	>0.30 m. of packed sand -- --	5154087.16	701062.20	video & photo
26	95/09/23	5.3	little current	3 to 4 metres visibility; soft silt over harder sand /silt mix; blue-green "sewage fungi" & 50 % filamentous algae; Core: 54 cm. (compacted 28 %); some gassing while removing core; soft, silty; extreme oil sheen/globules, strong petrochemical odour; coal tar - like globules, slight amount of fine fibre & detrital material.	1.60 1.75 1.50 1.25	>1.40 m. of clay >1.65 m. of clay -- --	5154121.61	700746.23	video & photo
27	95/09/23	13.0	no current	3 to 4 metres visibility; silty, very soft (diver sinks to knees; no vegetation; some resistance due to clay-like material; no rocks; Core: 50 cm. (compacted 33%); (0-40 cm. of oozy silt with < 5 % sand; no gas bubbles; very oily -globules/sheen; strong petrochemical odour; 40-50 cm. light brown, hard-packed sand).	1.10 1.30 1.50 1.30	>0.10 m. packed silt, no -- >1.15 m. packed silt --	5153897.27	700730.41	video & photo

GPS Fix Number	Date (Yr/Mo/Day)	Water Depth (metres)	Current Speed at 0.15 metres off bottom (metres/second)	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth (metres)	Nature & Amount of Material on end of Sediment Depth Probe	UTM Coordinates (metres) Northing	UTM Coordinates (metres) Easting	Record
28	95/09/23	2.4	--	4.5 metres visibility; 80 % vegetation (pondweed & < 5 % coontail) dusted with sediment; gassy; a few logs; some water mites & *Hexagenia* on sediment surface; Core: 50 cm. (compacted 30%); abundant gassing on retrieval; ver oily; strong petrochemical odour (0-7 cm. light brown with dark brown layer at 7 cm.; 7-50 cm. dark brown, silty sand & pink clay; 58-50 cm. black, oily gravel)	1.60 1.65 1.75	soft clay at 1.55 m. -- --	5153502.89	700344.40	photo
29	95/09/23	2.8	slight southerly current	4.5 metres visibility; consistent bottom is 85-90 % rock cover - small, round rocks/cobbles (10-30 cm.) % 10% large rocks; pea gravel among rocks; blue-gray clay particles; very little vegetation (pondweed & coontail); abundant snails & small crayfish; clam; stone flies; darters.	0.01-0.02 0.05 <0.05	-- -- --	5153241.71	700078.98	NA (no core)
30	95/09/23	10.5	south-west current	about 3 metres visibility; firm bottom with "pock" marks; few large boulders 3.0-4.5 m apart; clam; few small darters; Core: 16 cm. (compacted 38%)); light brown sand with 5-10 % silt, very little slag of very small size, & large gravel	0.50 0.50 0.50 0.45	no clay silt silt sticky silt	5152884.16	699820.44	photos
31	95/09/23	9.1	south-west current	1.5-2.0 metres visibility; sandy (95 %) bottom with wave dunes; some small coal chunks, small rocks & small slag pieces; probe hits rock or hard clay; a few small snails, clams; small stickleback; Core: 15.5 cm. (no compaction); (0-1 cm. of fine, light-brown sand; 1-15.5 cm. of coarser sand with few small rocks); no oil sheen; fishy odour.	0.10 0.15 0.10 0.15 0.15	no clay " " -- --	5152731.15	699653.56	photos
32	95/09/23	9.4	slight south-west current	2 metres visibility; rocky bottom; with 60% pea gravel, 30% large rocks & <5% large boulders (0.5 m^2); very little silty sand in between rocks; hard clay & small rocks encrusted with clay impede deeper probing; crayfish.	0.05 0.05 0.02	-- -- --	5152590.99	699489.58	NA (no core)

Table C-2. Bellevue Marine Park sampling station field notes and & diver's observations.
(Datum is NAD-27; accuracy for all locations is sub-metre).

Station Number	metres from Canadian shore	Water Depth, metres	Current Speed @ 0.15 metres off bottom * metres/second	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth ** (metres)	Nature & Amount of Material on End of Sediment Depth Probe
210	195	6.9	0.03 ± 0.01	flat bottom, pock-marked from escaping gas bubbles; surface is fine, fibrous and jelly-like material which is easily resuspended; area depresses when diver steps on it; very slow current; many small fish (Johnny Darters) and bowfin; diver sinks approximately 7.5-10 cm. into sediment; disturbance releases many gas bubbles and oil slick with strong petroleum odour; coring compacts sediment inside tube by about 50 % (two-fold).	>2.41	none
					>2.41	"
					1.75	"
					1.80	"
					>2.41	"
211	315	5.9	0.10 ± 0.02	fairly flat bottom, pock-marked from escaping gas bubbles; faster current than at Station 211; surface material is fine, silty, jelly-like and ~10 cm. deep; some macrophytes (*Chara* and *Elodea*) along "windrows" in the prevailing current direction; unionid (*Anodonta sp.*) and snail shell; disturbance does not release as much gas and oil slick (slight) as at station 210; coring compacts sediment inside tube by about 25 %.	1.25	light gray clay-like for bottom 0.60 m.
					1.40	"
					1.25	"
					1.75	light gray clay-like for bottom 1.50 m.
					1.25	light gray clay-like for bottom 0.75 m.
212	235	7.5	0.03 ± 0.02	fairly flat bottom, pock-marked from escaping gas bubbles; very slow current; surface material is soft, with fibres and wood pulp and jelly-like: diver sinks to ankles; some resistance to the probe at approximately 0.75 m.; some macrophytes (*Chara* and *Elodea*) along "windrows" in the prevailing current direction; snails, small fish (Johnny Darter); disturbance releases abundant gas bubbles; coring compacts sediment inside tube by 24 %.	1.00	gray clay-like for bottom 0.25 m.
					1.10	gray clay-like for bottom 0.50 m.
					1.40	gray clay-like for bottom 0.60 m.
					1.00	gray clay-like for bottom 0.50 m.
					1.45	gray clay-like for bottom 0.55 m.
					1.00	gray clay-like for bottom 0.50 m.
213	215	6.5	0.19 ± 0.02	flat bottom, with some pock-marks; faster current than at Station 212; fairly soft, fine, sandy surface material, but firm underneath; pieces of wood; a few depressions contain accumulated material due to back-eddying; only a single large rock in view ; light greenish tinge on sediment surface; burrowing mayfly larvae; small fish (Johnny Darter); probe hitting hard bottom releases some gas bubbles; stronger current than at station 212; coring compacts sediment inside tube by 14 %.	0.75	none
					0.40	"
					0.95	"
					0.90	"
					0.55	"

Station Number	metres from Canadian shore	Water Depth, metres	Current Speed @ 0.15 metres off bottom * metres/second	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth ** (metres)	Nature & Amount of Material on End of Sediment Depth Probe
214	90	1.0	0.10 ± 0.02	fine surface material with dense root mat, but hard underneath; large wood chips; filamentous algae; macrophytes (*Isoetes*); disturbance releases gas bubbles and very strong petroleum odour; coring compacts sediment inside tube by 39 %.	1.75	none
					1.45	"
					1.75	"
					~1.80	"
					1.70	"
215	300	5.9	0.11 ± 0.04	sand-silt surface material over firmer substrate interspersed with rock outcrops; some wood chips; sewage fungi and filamentous algae; macrophytes (*Chara*) and snails; small fish (Johnny Darter) and bowfin; some gas bubbles and very slight oil slick released by disturbance; greater current than at Station 214; coring compacts sediment inside tube by only 3-6 %.	0.85	none
					0.85	"
					0.85	"
					0.65	clay-like for bottom 0.04 m.
					0.95	clay-like for bottom 0.15 m.
216	100	6.4	0.25 ± 0.06	very flat bottom with a few rock outcrops offshore; about 1 cm. of very fine, silty material over very solid underlying material; disturbance releases some gas bubbles and oil globules to surface generating slight petroleum odour; coring compacts sediment inside the tube by 18 %.	0.90	none
					0.70	none
					0.85	clay-like for bottom 0.25 m.
					1.10	clay-like for bottom 0.45 m.
					1.15	clay-like for bottom 0.50 m.
217	580	2.0	0.10 ± 0.02	silty surface with a few pock-marks; diver sinks in about 10 cm.; rock underneath; slight current; 1.8-2.5 m. visibility; abundant macrophytes (*Potamogeton,Chara & Isoetes*); no gas bubbles released but sediment disturbance generates slight oil sheen on the surface; some petroleum odour in the benthos grabs; coring compacts sediment inside the tube by 7-11 %.	1.30	silt for bottom 0.75 m.
					0.85	none
					1.10	none
					1.20	silt for bottom 0.50 m.
					0.75	none
218	470	3.0	0.21 ± 0.05	Approximately 80 % large boulders with fine, silty sand in between or, in some areas, abundant small stones; faster current; some macrophytes (*Elodea & Potamogeton*); snails on stones; coring compacts sediment inside the tube by 27 %.	0.35	silt for bottom ...
					0.50	"
					0.55	"
					0.75	"
					0.95	"

Station Number	metres from Canadian shore	Water Depth, metres	Current Speed @ 0.15 metres off bottom * metres/second	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth ** (metres)	Nature & Amount of Material on End of Sediment Depth Probe
219	145	4	0	very soft sediment is easily resuspended and diver sinks in approximately 1 m.; harder material underneath; no current; about 100 % macrophyte cover (*Elodea & Potamogeton*) with snails; sediment disturbance releases abundant gas bubbles; coring compacts sediment inside the tube by about 50 %.	1.90	none
					1.80	"
					2.00	clay-like for bottom 0.50 m.
					2.15	clay-like for bottom 0.60 m.
220	120	3.0	0.02 ± 0.01	soft sediment - diver sinks in approximately 10 cm.; harder material underneath; almost no current; about 100 % macrophyte cover (about 80 % *Elodea* & 20 % *Potamogeton & Chara*); small fish (sticklebacks); sediment disturbance releases abundant gas bubbles and oil slick on surface; coring compacts sediment inside the tube by about 10 %.	3.30	none
					3.10	"
					3.20	"
					3.00	"
					3.00	"
221	305	5.5	0.21 ± 0.03	very soft jelly-like surface sediment with fibres over harder, more resistant, material (granular at bottom); approximately 40 % macrophytes (*Chara*) along "windrows" in the prevailing current direction; sediment disturbance releases abundant gas bubbles and oil slick on surface; free phase oil on water in benthic sample grabs; coring compacts sediment inside the tube by 50 %.	2.65	none
					2.65	"
					2.40	"
					2.40	clay-like for bottom 0.50 m.
					2.65	none
222	105	4.5	0.04 ± 0.03	very soft - diver sinks up to waist; very slow current; approximately 100 % macrophyte cover (mainly *Potamogeton*).	3.10	clay-like for bottom 0.50 m.
					3.25	clay-like for bottom 0.50 m.
					3.05	none
					2.95	clay-like for bottom 1.00 m.
223	295	3.4	0.07 ± 0.01	large boulders and cobble with 0.5 cm. layer of soft, very organic (black) silt over hard bottom in between; faster current; extensive weed bed at end of shoal under boat; approximately 100 % macrophyte cover (*Potamogeton & Vallisneria*) where present; freshwater sponge on underside of rocks; no zebra mussels; no gas bubbles released by sediment disturbance, but oil globules released to surface have oil/petroleum odour and form slick; coring compacts sediment inside the tube by about 25 %.	0.75	none
					0.25	"
					0.65	"
					0.65	"
					0.50	"

Station Number	metres from Canadian shore	Water Depth, metres	Current Speed @ 0.15 metres off bottom * metres/second	Sediment Characteristics (type, consistency, presence of sewage fungus, macrophytes, invertebrates, debris, oil, etc.)	Sediment Depth ** (metres)	Nature & Amount of Material on End of Sediment Depth Probe
224	295	6.1	0.07 ± 0.05	very pulpy, jelly-like bottom with pock-marks that bounces where diver walks; very soft surface sediment containing fluffy fibres - diver sinks in to knees - with very solid material (rock?) underneath; low current; no macrophytes, but some unrooted *Potamogeton* present which probably drifted in; small fish (Johnny Darter?); sediment disturbance releases very abundant gas bubbles and large oil slick; coring compacts sediment inside the tube by about 25 %.	1.60	none
					2.00	"
					1.75	"
					1.95	"
					1.45	"
225	125	5.3	0.02 ± 0.01	very soft, pock-marked bottom - diver sinks in to knees or crotch - with fairly firm material (clay?) underneath which gives way to softer material when depth probe is pushed in further; low current; visibility about 2 m. decreases to 0-1 m. when sediment is disturbed; sewage fungus on surface (approximately 80 % coverage), with the occasional loose macrophyte sprig (*Elodea*); some snails; sediment disturbance releases abundant gas bubbles and large oil slick; coring compacts sediment inside the tube by 50 %.	2.75	none
					2.75	"
					2.65	"
					>3.30	"
					2.65	"
226	95	3.3	0.10 ± 0.05	fairly soft, very fine surface sediment which is easily disturbed - diver sinks in to ankles - with harder material (silt?) underneath; increased current; 100 % macrophyte cover (dominated by *Elodea, Chara* & *Potamogeton*; *Vallisneria* also present); snails on macrophytes; sediment disturbance releases gas bubbles and oil slick to surface; coring compacts sediment inside the tube by about 25 %.	3.00	none
					3.10	"
					3.10	"
					3.10	"
					3.30	"
227	220	6.0	0.37 ± 0.05	flat, very soft and fibrous bottom - diver sinks to mid-calf - with firmer material at approximately 1.0 m. depth; faster current; visibility 1.5-1.8 m.; no macrophytes; chironomid present; pressure on sediment releases very abundant bubbles and oil slick with strong petroleum odour to surface; bubbles also bring up fine wood fibres; coring compacts sediment inside the tube by 49 %.	>3.30	none
					>3.30	"
					>3.30	"
					>3.30	"
					>3.30	"

NOTES: "*" current speed values are the mean and standard deviation of a minimum of three determinations by Marsh-McBirney meter over a 30 minute period.
"**" replicate sediment depths obtained by diver pushing a metal rod in to refusal at four to six spots within= the immediate area.

APPENDIX D

Table D-1. Layer information for Bellevue Marine Park area digital drawing file (Figs. 2,4 and 6).

LAYER DESCRIPTIONS FOR BELLEVIEW AREA FINAL DRAWING (SDWNFIN.DWG)		
LAYER No.	LAYER NAME	DESCRIPTION
0	0	no data
1	ASHADE	no data
2	BLUE	blue lines in the title block
3	COORDS	geographic and UTM grids
4	GAS	zones of penetration, division lines
5	GASHATCH	no data
6	HATCH	fine sediments (lithology)
7	HATCH1	no data
8	HATCH11	no penetration due to gas, weeds etc.
9	HATCH2	weeds on gravel and boulders (lithology)
10	HATCH22	partial penetration but gas masking
11	HATCH3	heavy weeds (lithology)
12	HATCH33	no penetration due to bottom type or lack of overburden
13	HATCH4	fine sediments with gravel and boulders patches (lithology)
14	HATCH44	penetration to bedrock or till
15	HATCH5	sand, gravel and boulders (lithology)
16	HATCH6	fine sediments with sparse weeds (lithology)
17	HATCHING	no data
18	KEYGAS	penetration hatching legend
19	KEYLITH	lithology hatching legend
20	LITHOLOGY	zones of lithology, division lines
21	MANMADE	anthropogenic features
22	NARROW	north arrow (referenced to UTM grid)
23	RED	red lines in the title block
24	RUNLINES	track plot with positional fix no.
25	SAMPLE	sample position numbers
26	SAMPLES	sample position symbols
27	SHORELINE	shoreline boundaries
28	TEXTBLK	text in title block
29	TTLEBLK	title block

Table D-2. Layer information for Algoma Slag Dump-Algoma Slip digital drawing file (Figs. 3, 5 and 7).

LAYER DESCRIPTIONS FOR ALGOMA AREA FINAL DRAWING (SUPFIN.DWG)		
LAYER No.	LAYER NAME	DESCRIPTION
0	0	no data
1	BLUE	blue lines in title block
2	GASKEY	penetration hatching legend
3	HATCH1	fine sediments (lithology)
4	HATCH11	no penetration due to weeds, gas, etc.
5	HATCH2	weeds on gravel, boulders, sand (lithology)
6	HATCH22	partial penetration but gas masking
7	HATCH3	heavy weeds (lithology)
8	HATCH33	no penetration due to bottom type or lack of overburden
9	HATCH4	sand, gravel and boulders occasional cobbles (lithology)
10	HATCH44	penetration to bedrock or till
11	HATCH5	fine sediments with weed patches (lithology)
12	HATCH6	sand and gravel on glaciolacustrine clays (lithology)
13	HATCH7	worked glaciolacustrine clays
14	KEYLITH	lithology hatching legend
15	NARROW	north arrow
16	RED	red lines in the title block
17	SAMPLEPOINTS	sample position symbol
18	SUPCONT	contour lines
19	SUPGAS	lithology hatching legend
20	SUPGEO	geographic grid
21	SUPLITH	zones of lithology, division lines
22	SUPMAN	anthropogenic features
23	SUPSAMP	sample position numbers
24	SUPTRK	track plot with positional fix no.
25	SUPUTM	UTM grid
26	TEXTBLK	title block text
27	TITLEBLK	title block